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Comparison of Wind Tunnel Results for Two Active Aerodynamic Load Control Devices

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Abstract

We modified the wind tunnel setup at LM Wind Power to be able to investigate airfoils with **movable trailing edges**. This allowed us to test two different trailing edge concepts on the same base airfoil, and compare their characteristics. The first concepts was a **rigid trailing edge flap** extending 10% of the chord length. The second concept was a **miniflap** extending only 1% of the chord length, but with a deflection angle up to 90°. The flaps could be moved with a reduced frequency of up to 0.2 (4 Hz) at a Reynolds number of 3 million (50 m/s), which represents realistic flow conditions on a modern turbine blade.

Experimental Setup

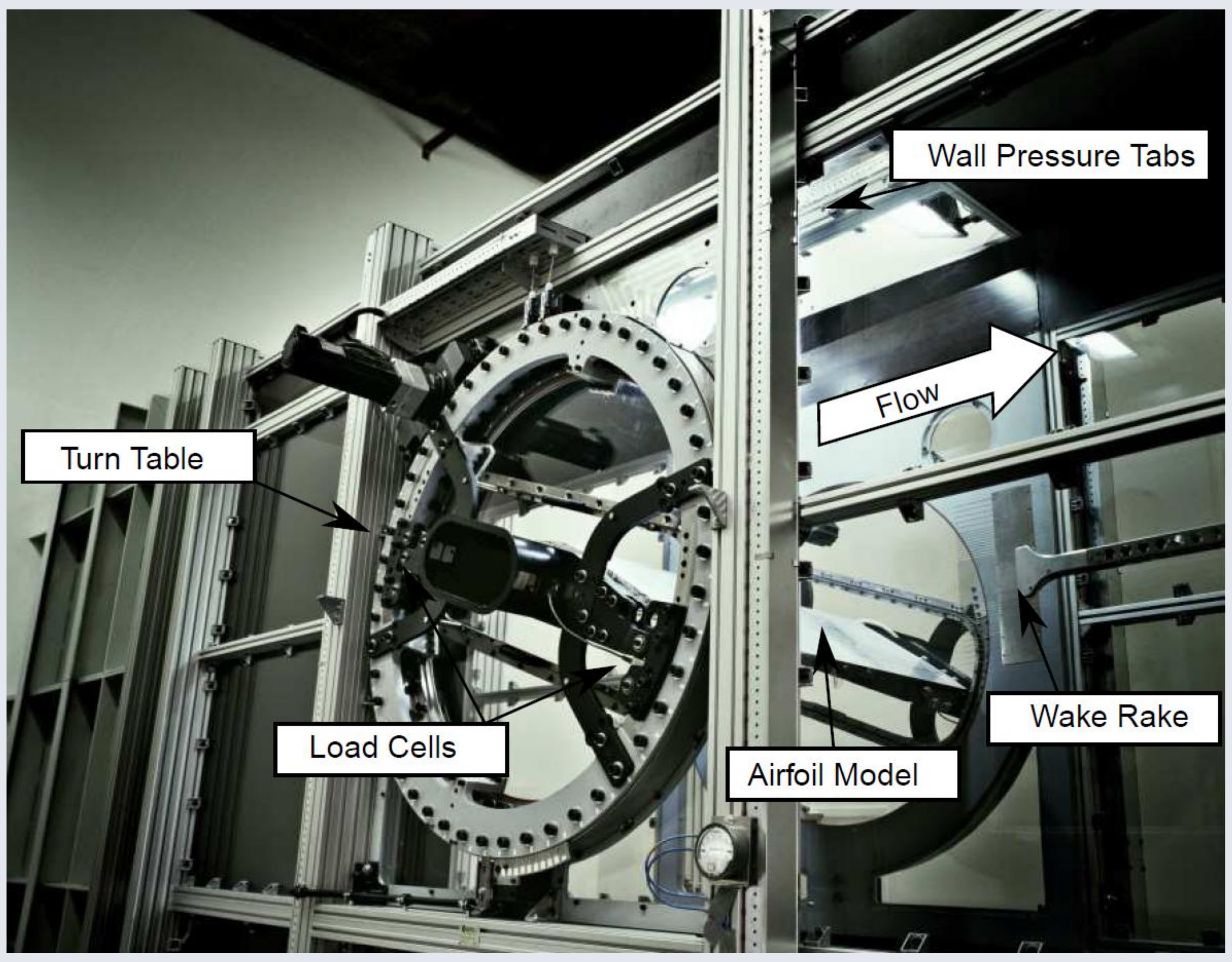


Figure 1: The LM Wind Power Wind Tunnel features flow conditions similar to those on a modern wind turbine blade. The airfoil forces were measured using two independent systems, **pressure tabs and load cells.**

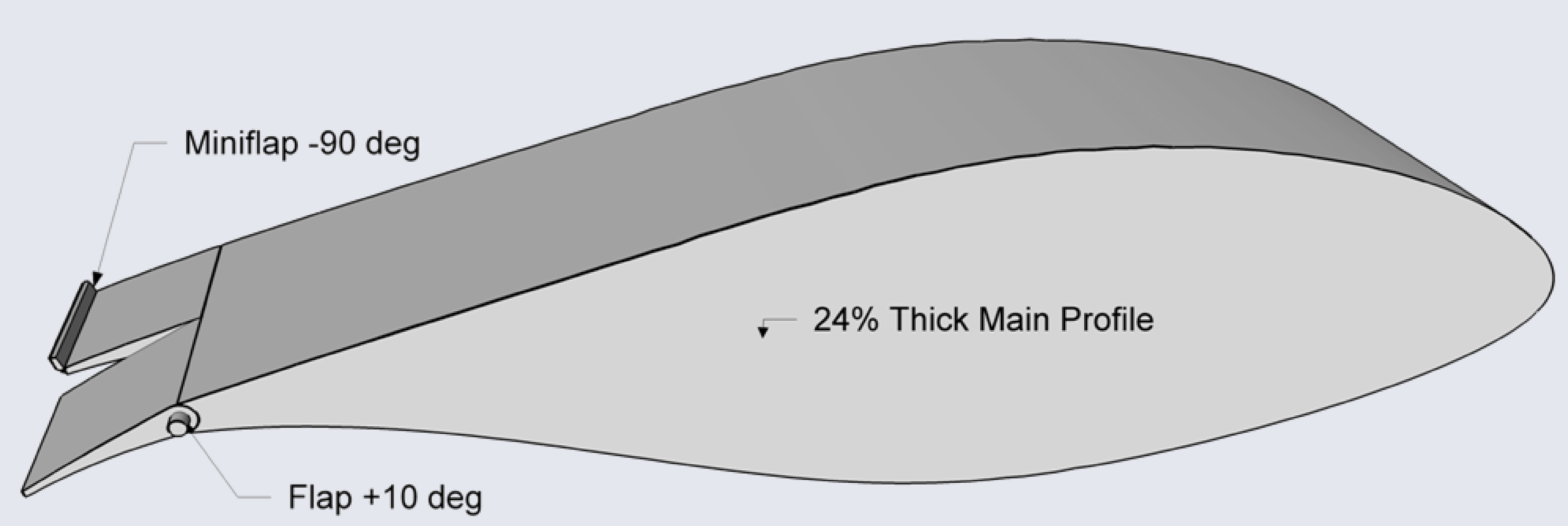


Figure 2: Sketch of the main profile and two trailing edges, deflected. A servo motor was used to move the devices in a harmonic motion at **frequencies up to 4 Hz (*k*=0.2)**.

Steady State Measurements

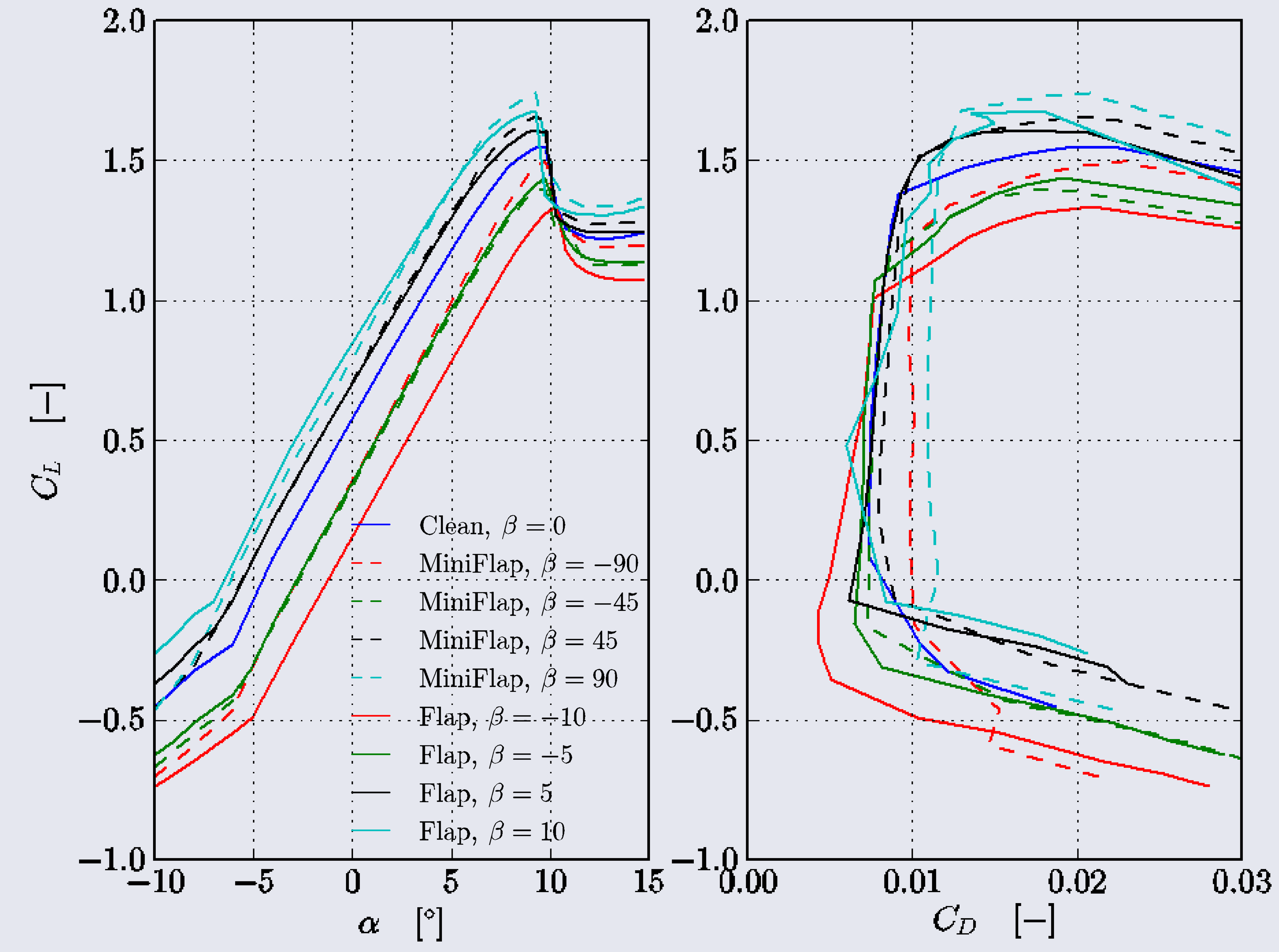


Figure 3: Steady state measurement for various angles of attack, and various deflection angles.

Unsteady Measurements

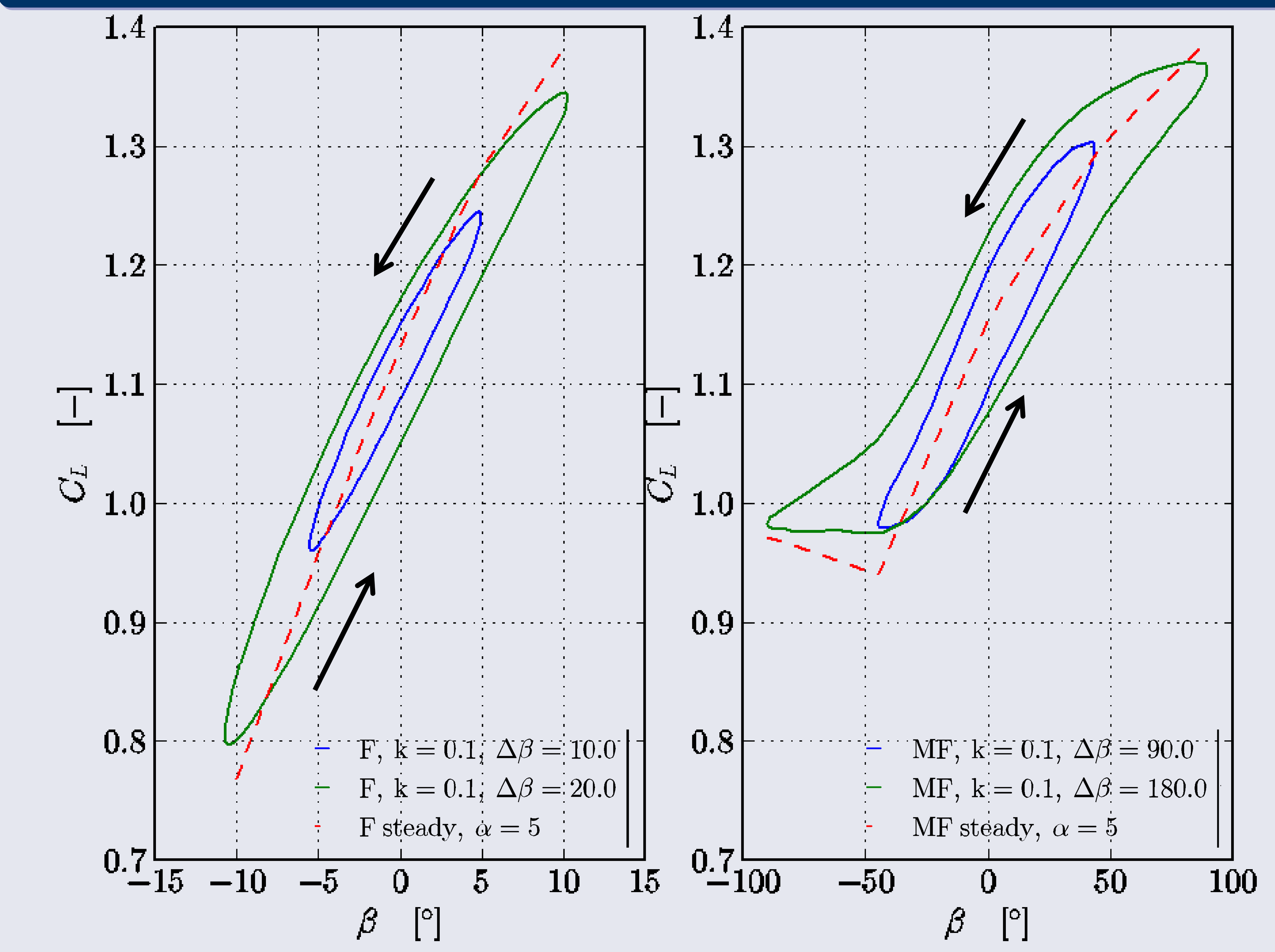
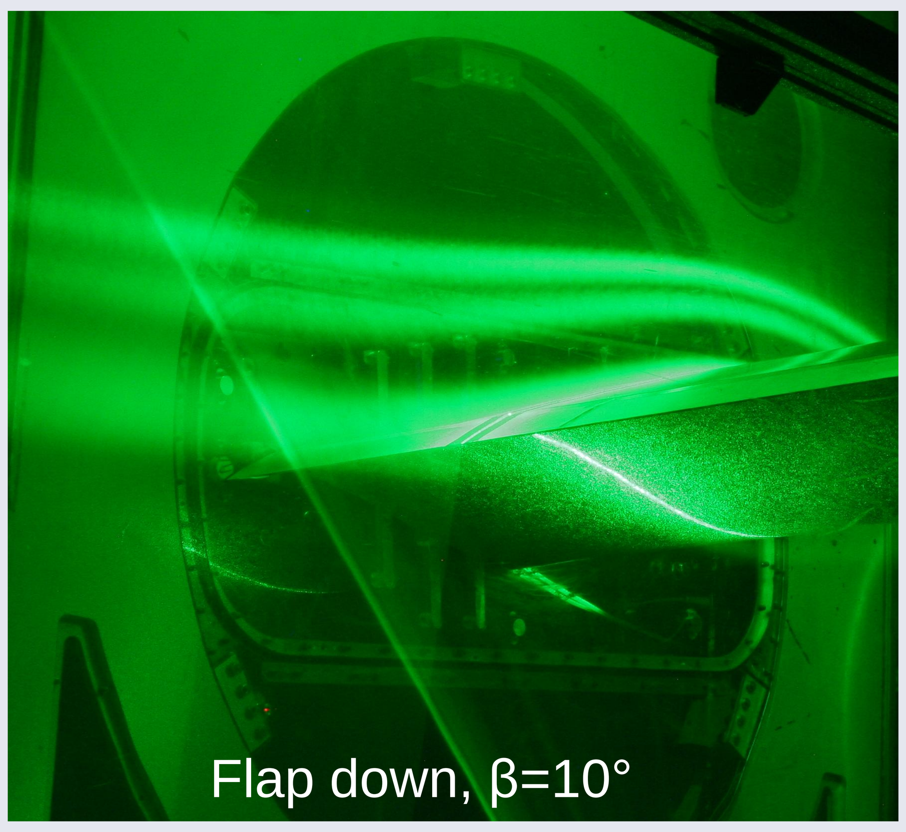
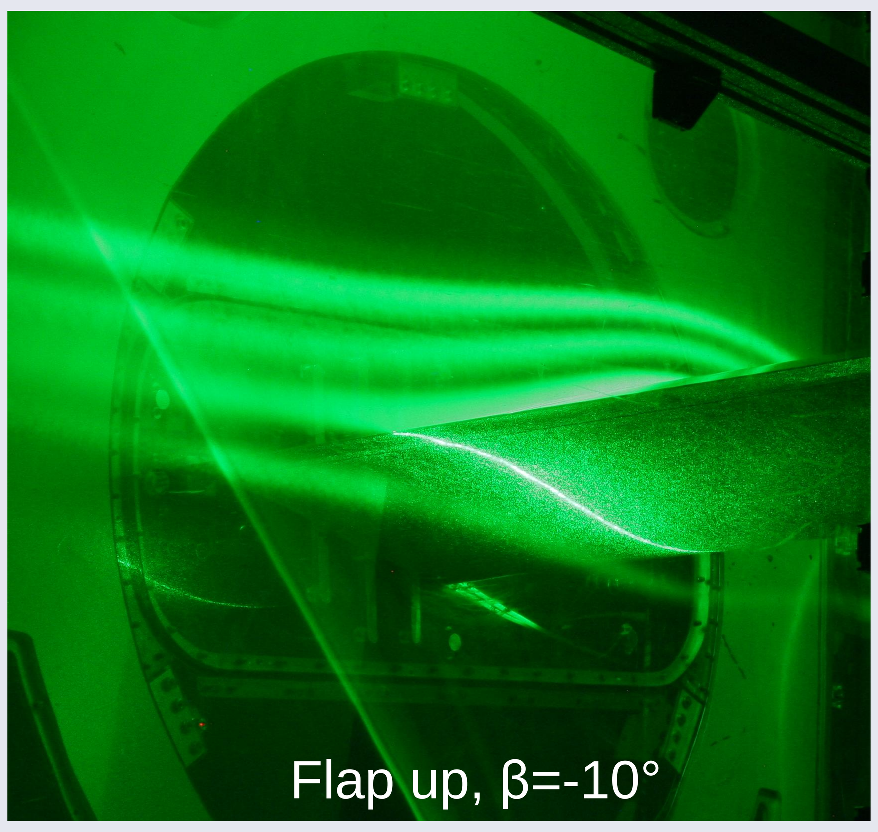


Figure 4: Right: flap. Left: Miniflap. Unsteady measurement at 5 deg angle of attack. Flap motion is sinusoidal. **The unsteady aerodynamics create a hysteresis in the forces at high reduced frequencies.**

Streamline Visualization Using Smoke, α=5°





Conclusions

- **The flap has a higher range of C_L for a given angle of attack, than the miniflap and the flap has a lower drag than the miniflap**. A device with a large range of C_L is well suited for controlling the loads on a turbine blade.
- **The hysteresis loop of the lift force is due to unsteady aerodynamic effects in the wake**. The higher the frequency becomes, the wider the loop becomes. A reduced frequency of *k*=0.1 is realistic for a turbine blade. The effect of unsteady aerodynamics is important to model to do correct aeroelastic simulations of active load control.